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The differences between two hospital's level of productivity and quality of care were investigated to determine if efficiency in hospital design, and modern technology, provide increases in either of these factors. The study consisted of a study of a single organization as it operated the last 24 months of its 44 year occupancy in a mobilization-style Army hospital and the first 9 months of its occupancy in a new mall-concept-style hospital. The results indicated that an increase in productivity was not seen. The aggregated data for the nine month period showed no significant increase in output and showed very unstable relationships between the outputs and the inputs used to produce them. The results indicated that an increase in labor caused a decrease in outputs and an increase in spending only caused one half the increase in outputs that it had in the first facility. In addition, no definite decision could be made regarding the quality of care delivered because although some variables demonstrated an improvement, other very important indicators demonstrated a decrease in the quality of care. The findings are probably a result of insufficient sample size and the impact of the initial adjustment period on the aggregate data in the new facility.

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HOSPITAL DESIGN'S INFLUENCE ON

PRODUCTIVITY AND QUALITY OF CARE

A Graduate Research Project
Submitted to the Faculty of the
U.S. Army-Baylor University Graduate Program
in Health Care Administration
in Partial Fulfillment of the Requirements for
the Degree of Master of Health Administration

By

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July 1987

Acknowledgments

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Chapter I

Introduction

Productivity has become a major concern of U.S.
industry in recent years as evidenced by the
proliferation of literature on the topic in the major
business periodicals (Business Week, Management Review,
The Journal of Business Strategy, Personnel, Business
Horizons, and Management World, etc.) and for good
reason. Although the United States remains the leading
world producer, Buffa (1983) tells us that the edge once
held in this arena by domestic industry is becoming
increasingly smaller. Buffa cites the fact that while
Japan's average annual increase in productivity has been
about seven percent over the last few years, United
States productivity level increases were only one
to two percent. In addition to competition from other
major industrial nations such as West Germany and Japan,
Naisbitt (1982), in his book Megatrends, notes that
competition is also being exerted from Third World
nations. He states that "the 20 fastest-growing
economies for the period 1970-1977 were all Third
World countries." (p. 61). He emphasizes that this is
not a one year occurrence, but rather a trend over the

past decade and a half whereby the slowdowns in industrial productivity in the United States have been accompanied by dramatic increases in productivity in the Second and Third World nations.

In defense of our economy, Naisbitt (1982) and Buffa (1983) argue that our production base has shifted toward the service economy and away from the industrial based economy which has been the reported portion of the production base. This discounts the cries of our falling productivity levels. With this in mind, the need for managerial methods to quantify, measure and enhance service industry productivity becomes apparent (Sherman, 1984). However, unlike the production process of the industrial economy, Sherman (1984) tells us that service business productivity is more difficult to measure because it is often difficult to determine the optimum efficiency level of specific inputs which are necessary to produce service outputs. He offers the reasoning that often professional judgement is involved in the determination of which inputs are necessary in the process of service production. Judgments of this nature are subject to criticism because of their subjective nature. Because of this, a lack of consensus

sometimes occurs regarding the standardization of input and output measurement (Sherman, 1984).

The health care arena, being a subset of the services sector, offers significant difficulty in the determination of productivity. The crux of this problem stems from the difficulty in determining the definition of outcome which results from the health care processes. Donabedian (1980) defines outcomes as "a change in a patient's current and future health status that can be attributed to antecedent health care." (p. 82-83)

He further refines the definition by postulating that health includes improvement of social and psychological function, physiological aspects of performance, patient satisfaction, health related knowledge and health related behavioral change. Although the literature demonstrates that the measurement of these elements is a monumental task both in the aggregate and separately (Costanzo and Vertinsky, 1975; Donabedian, 1980; and Sherman 1984), use of surrogate variables has been the common practice among researchers in this area.

The topic of productivity remains of high concern

in the service sector because general agreement exists that productivity, meaning the ratio of inputs to outputs, in this sector has not increased as it has in the industrial sector (Buffa, 1983). Buffa states that the area of health care, as a subset of the service sector, has been targeted by critics particularly because of the rapidly rising costs associated with it. He cites the facts that health care cost expenditures have more than doubled in the last decade, increasing at a rate of almost 13 percent per year.

Conditions Which Prompted the Study

The Department of Defense (DOD) health care sector has not been immune from the criticism of health care expenditures. David West, President of Health Care Corporation of America/Government Services Incorporated and past member of the Blue Ribbon Panel on Sizing DOD Medical Facilities, cited several examples of what he termed "financial waste(s) of great proportions" revealed during their study (Tomich, 1986). He makes the comparison that it cost the Veterans Administration five times as much to build a nursing home and twice as much per day to run it than the private firm of Beverly Enterprises, and that in 1984 it cost DOD hospitals

approximately $8 billion to care for an average daily census of 14,000 patients while HCA spent only $2.3 billion to care for the same average daily census.

All of this demonstrates that with the possibility of even further cuts to the defense budget due to Public Law 99-177 (The Balanced Budget and Emergency Control Act of 1985) or the Gramm-Rudman-Hollings Bill, the availability of funds for health care within Department of Defense may become more scarce in the future. Since dollars for construction costs can be cut with far less public outrage than dollars for patient care, the obvious area for cutbacks becomes that of hospital construction and renovation. The foremost example of this today is the issue of Brooke Army Medical Center (BAMC). The point of contention was whether to build a 495 bed facility or to decrease the number of hospital beds in the military sector in the San Antonio area instead by limiting the capacity to between 325 and 175 beds. Although the BAMC issue is a concern of overbedding and not one of productivity, it emphasizes the point that substantial justification of future expenditures, to include that of construction, will become increasingly more critical. In the future, it

will be incumbent upon the health care administrator within the federal sector to demonstrate that funds spent in this manner do in fact lead to greater productivity and/or increased quality of care in order to justify their expenditure.

The purpose of this research is to compare the productivity levels of the 42 year old World War II, contonement-style hospital in use at Fort Carson, Colorado until July 1986, with the new mall-concept-style hospital which was occupied after that date. (Fiscal Year 1982 Military Construction Project Data). It is not the primary intent of this research to address the pros and cons of various facility designs, but rather to address the question of whether there exists an increase in productivity and/or quality of care as a result of a move into a new facility of a more modern design. Significant improvements in either of these areas would suggest justification for their expenditure and for future projects.

Statement of the Problem

To determine if use of the newly constructed Evans Army Community Hospital, Fort Carson, Colorado will

result in increases in productivity and/or quality of care as compared to the levels recorded in the former facility.

Objectives

The objectives which must be achieved to accomplish this research project are as follows:

1) Determine what data elements will be used as surrogate variables to represent the exogenous and endogenous variable components of productivity and quality of care.

2) Determine what sources within the hospital can best provide this data with the greatest reliability.

3) Collect productivity and quality of care data elements for a period of 24 months prior to the move to the new facility and 9 months afterwards.

4) Develop a matrix, using the data collected, to provide for statistical analysis of both the dependent and independent variables which have been gathered for each hospital.

5) Analyze data.

Criteria

Changes in productivity and quality of care indicators will be considered significant at the .05

level to provide a 95 percent confidence level in the conclusions surmised through the use of the statistics analyzed.

Assumptions

1) The data elements selected, accurately reflect a relationship of exogenous to endogenous variables.

2) The data elements collected have been accurately reported for each variable selected.

3) Inflation has had negligible impact on the cost variables over the time period of the study due to the fact that it has remained in the low single digits since 1984.

Limitations

1) Variable data that has been aggregated across one month may not accurately reflect quality of care due to the broad range in severity of the incidences that the indicators measure.

2) Most variable data representing quality of care have been gathered solely for inpatient services, whereas, variable data collected for productivity have been collected for both inpatient and outpatient service

Chapter II

Discussion

Having established the fact that productivity is of importance to the health care industry today, we need to look particularly at the Department of Defense where funds appropriated for upgrading hospital facilities face intense review as Public Law 99-177 becomes administered.

Literature Review

Hospital Design

Before the study of productivity in the two hospitals was begun, the reasoning behind the expected increase in productivity levels needed to be addressed. The justification provided by the Army Medical Department, Health Facilities Planning Agency on DD Form 1391, Military Construction Project Data, dated 5 December, 1979, states:

> "this project is required as a replacement for a hospital of mobilization type design consisting of 35 buildings constructed in 1942. A modern, well-planned facility is required to provide medical care to troops of the modern Army as well as other authorized beneficiaries and to provide

for more effective and economical operation. Due
to the dispersion of present buildings, excessive
time is lost by hospital staff personnel in the
performance of their duties between sections.
This also causes inconvenience to in- and
out-patients. The existing hospital plant is not
compatible with the current mission economically
modified to meet current standards." (p. 1)

McLelland (1985) relates the information that
Florence Nightengale provided regarding hospital design
and efficiency from her "Notes on Hospitals" published
in 1863. She comments that with a supply of hot and
cold water all over the building, a ward could be
expanded to care for from 20 to 32 patients with
the reduction of an attendant. These early comments
regarding hospital design and efficiency lend credence
to the theory that certain modernizations in design
should result in an increase in the productivity of an
organization.

Design specifics which have been purported to
maximize productivity are varied in nature and apply to
both individual units, as well as the facility as a
whole. Skaggs (1984) proposes two nursing units

configurations that are considered to be the most efficient. The first is described as a modified triangular unit and the second is rectangular in shape and is often called the "race track" because of its central positioning of the nurses station while the corridors and patient rooms surround it. The "race track" design is the configuration of the majority of the nursing units in the new facility. The exceptions to this design are the Intensive Care Unit and the Recovery Room where the beds are arranged in a linear fashion due to the obvious need for direct observation of the patient bed from the nursing station. The configuration of the wards in the old hospital was that of the more traditional design whereby the nurses station was located at one end of the ward and the patient rooms were located to the left and right off a hallway which ran the length of the building. This created the situation whereby the nursing staff had to traverse the entire length of the corridor numerous times during the shift to attend to patients at various locations on the ward.

In addition to the nursing unit configurations, Skaggs (1984) recommends careful attention to the

placement of nursing units and ancillary services within the hospital. For instance, he speaks of the need for interface between the outpatient and the main surgical suites and therefore the need to closely locate these services. In the new facility, these two areas are co-located, however, in the old facility there was no provision for outpatient surgery other than those types of procedures which could be performed in the clinic setting without backup anesthesia support. This prohibited these procedures from being done anywhere but in the main surgical suites which restricted the amount of surgery possible in a day and required the admission of the patient.

Support for this concept is provided in a similar vein by Panther (1985), who recommends locating ancillary services common to both inpatient and outpatient in a manner such that they are easily accessible by both. He offers the explanation that the minimization of cross traffic accomplished by this design achieves a higher level of productivity as well as providing added convenience to the patient. The new facility design makes maximum use of this concept by locating the pharmacy, treasurer, chapel, eating and

shopping facilities, library and the Civilian Health and
Medical Program for the Uniformed Services (CHAMPUS)
office in the area known as the Commons. Just adjacent
to the Commons are other ancillary services used by both
inpatients and outpatients. These services are
radiology, laboratory, physical therapy and occupational
therapy. In the old facility these services were spread
across over one mile of buildings and corridors.
Figures 1 and 2 are diagrams of the layout of services
within both of the facilities to provide a better
understanding of the lack of centralization in the old
hospital versus the new.

Another researcher, Cluff (1979) recommends the
consolidation of inpatient units in one area of the
hospital and outpatient in another. This concept is
achieved in the design of the new facility where the
outpatient clinics are located in the south building and
the inpatient units are located in the nursing tower
with the Commons area adjoining the two.

In addition to benefiting from the advantage of
reduction in cross traffic through the co-locating of
ancillary services, Kuntz (1984) cites design
efficiencies espoused by a number of architectural

firm's executives that are features of the new
facility. Roy Fridberg, vice president and partner of
New York firm, says that an improvement in efficiency
can be achieved by reducing the distances workers have
to travel within the facility. Ronald L. Skaggs,
executive vice president of a Dallas firm gives figures
that show that horizontal facilities reduce the travel
time of the hospital employee. He says that a cart
can be pushed a distance of 260 feet in a minute and the
time it takes to push and elevator call button and
travel the distance to the next floor averages about 48
seconds. This distance traveled is about 15 feet, where
in the same amount of time, approximately 200 feet could
be traversed horizontally. (p. 1) Tusler, president of
a San Francisco based firm, however, notes that
horizontal benefits only extend to a point. He states
that at some point the building becomes too long or wide
and loses efficiency. This point can well be
demonstrated by the distances patients had to travel in
the old hospital. The inpatient and outpatient services
were spread across a bi-level distance of almost two
miles (US Army Engineer District, Omaha, August 1985).

With all the seeming inefficiencies in the

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configuration of the old facility, the design had its
purposes. The facility was built to accommodate World
War II injured soldiers. Because of the war time
threat, the building was designed so that a single
bomb would not destroy a major portion of the hospital.
Although this concept had merit in its day, full
integration of the technological systems necessary for
the provision of health care today would most likely
require a total replacement of the facility. This
statement mirrors the opinion of Paul Brown (1984)
regarding the modernization of hospital facilities.

In addition to the efficiencies inherent in the
facility layout, many functional amenities were included
in the design to facilitate daily operations. On the
nursing units nurse servers were installed. These
devices are storage lockers located in the patient room
designated for each patient bed. They contain supplies
used daily by the nursing staff. For instance, linen,
dressings, disposable basins, water pitchers and cups.
These are stocked daily by materiel personnel. When
these items are needed by nursing staff, they are then
retrieved from the nurse server rather than traversing
the ward to the supply closet for each individual

patient need.

Nursing units were also equipped with time saving devices that were included in other areas of the hospital. These include items such as a box transport system and a pnuematic tube system for movement of patient records, laboratory specimens, pharmaceutical prescriptions and many other like items. Also available in most areas of the hospital are Omnifax machines that transmit photocopies electronically to any other area that has an Omnifax machine. These machines are excellent for transmitting stat lab request results from the laboratory to the emergency room and for arterial blood gas test results from respiratory therapy to the ward or emergency room. The particular advantage of this device to these areas is that both the laboratory and respiratory therapy are located across the commons from the wards and the emergency room.

All of these design improvements suggest improved productivity in the new hospital. The Hospital Engineering Handbook (1980) published by the American Hospital Association supports this supposition in the following statement "the working environment has a direct effect on how efficiently employees work"

(p. 250) But, increased productivity can not be
expected from the first day of occupation in the new
facility. An initial drop in efficiency levels is
expected because of the surroundings of a new
environment. Locations of supplies, procedures for
operating new equipment, telephone numbers and physical
layout of other departments are all things that will
take time to learn and until that time, will put an
additional drain on resources.

This phenomena can be explained through the
psychological concept of the learning curve (Mussen et
al., 1973). As the graph in Figure 3 shows, the curve
results from the learning by the subject of all the
items previously recalled plus a constant fraction of
the items yet to be learned. In the new hospital
setting, this learning process occurs in the same manner
as demonstrated by the learning curve; adding new
knowledge each day to that which has already been
mastered. Over time, this would result in increased
efficiencies from that of a previous period. Because of
the need to learn the "system" of the new facility,
which is used to denote a composite of all tasks to be
accomplished by an employee, a drop in productivity

would most likely be experienced from levels in the old facility prior to the move upon initial occupation. This would be due to the simultaneous abandonment by the entire organization of the "system" that had been in existence in old facility. As the new facility becomes more familiar to the employees, then a gradual increase in productivity should be experienced.

This same concept can be explained by what economists call the production curve. As can be seen in Figure 4, the production curve mirrors that of the learning curve. Mansfield (1977) defines this theory as the relationship between the quantities of various inputs used per period of time and the maximum quantity of the commodity that can be produced per period of time. In other words, as employees learn the "system" of the new facility, they use fewer manhours and supplies to accomplish the same task thereby increasing productivity of the unit.

When the point in time is reached that the employees have reached the upper part of these curves and a leveling effect in the productivity occurs. From the research presented, it is suggested that because of the efficiencies inherent in the design of the facility,

this level of productivity reached should be greater than that previously experienced in the old facility.

One factor which could possibly detract from the expected increase in productivity in the new facility would be if the increased efficiencies resulted in increases in the quality of care being delivered instead of the increases in productivity. Bartscht and Coffey (1977) imply this and Morris (1980) suggests the same. The justification for this increase in quality of care is explained by Donabedian (1980). He says that the amenities of a facility, which are perceived to abound in a new facility, can positively effect the employee's and patient's attitudes. This then improves the quality of care being delivered and the perception of that care. The change in the perception of care is best explained by what is known as the Hawthorne effect. Both Adair (1984) and Machol (1975) explain the effect in the following manner. Subjects react according to the role they perceive that they are in. This translates to an improvement in the care being delivered when new facilities, supplies and equipment are being used because of their relation to high technology. Since perception of care plays a major role in patient

satisfaction, that perception alone has an impact on the quality of care.

Productivity

Before a study can begin to determine the levels of productivity in both facilities a definition of productivity and quality of care must first be determined, then a means of measurement must be decided upon.

The general consensus from the literature is that productivity is a measurement of the inputs used to produce outputs (Mansfield, 1977; Sherman, 1984; Buffa, 1983; Suver & Neuman, 1986; Channon, 1983; Pauly, 1970; and Berki, 1972). Berki (1972) uses this terminology then to discuss a formula known as the production function which is symbolically expressed as:

$$q = f_1 (x_1, x_2).$$

The output, "q", denotes that it is a function of the combination of inputs x_1 and x_2. This most basic of all production formulas will be used throughout the study as the basis for my analysis.

The adaptation of this formula to the health care environment may appear to be simple initially. However, as discussed in the introduction, obtaining a consensus

on what the inputs and outputs are in the hospital
setting and the measurement of these variables becomes a
tremendous challenge. The definitions provided by
Mansfield (1977) are very broad. He defines inputs as
"anything a firm uses in its production process"
(p. 143-144) and outputs as the completed product or
service.

Outputs. If we accept Donabedian's (1980)
definition that the outcome of health care is a change
in the patient's health status and that health relates
to anything from psychological and social function, to
physiological aspects of performance, to patient
satisfaction to health related knowledge and behaviors,
the realization occurs that a formidable task is at
hand. Rarely will you find in the hospital environment
an attempt to measure any of these factors except
patient satisfaction, but again that is rarely done with
any consistency nor is it based on quantifiable,
pre-established standards. Without a consensus or
measurable outcome variable, determination of the inputs
for which that outcome is a function, becomes
impossible.

The first step in this process must then be to

determine surrogate elements which approximate the
outcome of improved health status and that also can be
measured. Berki (1972) provides an indepth review of
the literature is this area and concludes that there are
six approaches to the definition of hospital outputs.
These are as follows:

1) patient days, weighted or unweighted,

2) weighted hospital services,

3) episodes of illness,

4) end results and health levels,

5) intermediate inputs to attainment of the highest
level of health status, and

6) composites of one or more of the above (p. 33)

Since it has already been established that
measurement of health levels or health status have not
yet been developed in the hospital industry, the first
three options are those that need to be examined.
Okafor (1985) cites Blumberg and Gentry (1978) as saying
that use of the patient day is the traditional index of
hospital outcome. Of course, the unweighted patient
day, along with mere counts of episodes of illness fail
to take into account the intensity of the service inputs
necessary for an incident of care and therefore does

not adequately describe the relationship between the inputs versus the outputs of that incident. Weighted hospital services was not considered a viable measure either. These are estimated through the use of counts of the number and type of x-rays, laboratory tests, pharmaceutical prescriptions filled, consumable supplies used and so forth, for each patient. Berki (1972) points out that the major problem with this approach is that the weights are derived from the average cost of each service and not from the benefit that the patient derives from the service. The measure considered to be the most desirable then, was that of the weighted patient day. Berki (1972) cites the use of the International Classification of Diseases which is the basis for the currently used Diagnostic Related Groupings (DRG's). Because of the use of weightings by disease considerable detail is available with this system. Unfortunately, patient charts were not screened using these guidelines in the military sector during the initial time period involved in the study. Berki (1972) also cites an alternative weighting of patient days that accounts for a variety of types of patient days in use in the United States Army. This measure is termed a

Medical Care Composite Unit (MCCU) and is derived from the following formula specified in Change 1 to Health Services Command Supplement 1 to Army Regulation 37-100-86:

"beds occupied x 1 / the number of days, plus

admissions x 10 / the number of days, plus

live births x 10 / the number of days, plus

clinic visits x 0.3 / the number of days." (p.B40)

With the advantages of the weighting used in this measure and the availability in the hospital under study, the MCCU became the primary choice for the measure of hospital outcome.

Inputs. Determination of the inputs that make up a patient day is not nearly as difficult to gain consensus. The literature shows that the use of some type of cost figure and manhour figure are generally agreed upon. Shear (1981) suggests the use of manhours worked and payroll costs. Suver and Neuman (1986) instead use salaries, equipment costs and nursing hours. Feldstein (1971) uses real capital and labor inputs in his computations. Ro (1969) uses staffing ratios and consumption of supplies. Perrin (1983) looks at supply and equipment costs; while Sherman (1984) uses

manhours and supply dollars. Finally, Harju and Sabatino (1984) review the use of salaries and staffing ratios. Since all of these measures except staffing ratios were readily available on a monthly basis for both hospitals, it was decided that they would be included in some manner in the data collection effort, with the one exception of the staffing ratio.

Quality of Care

With the possibility that the increased efficiencies in the new hospital may result in an increase in the quality of care rather than increases in overall productivity, a means of measuring the quality of care being delivered had to be determined. Cromwell (1974) cites reference to this possibility in work done by Feldstein (1971) in his computation of annual productivity increases. He uses real capital and labor inputs per patient day between the years of 1955 and 1968 in a variety of medium size hospitals. He determined a 3.8 percent annual decrease in productivity. This percentage was only representative if there had been no change in the product. Cromwell (1974) then postulates that some of that decline in productivity was actually due to an increase in the

quality of care delivered.

In that same publication, Cromwell (1974) acknowledges the lack of a consensus on the definition of "quality care". If Donabedian (1980) is looked at once again, quality of care can be defined as anything that improves an individual's health status. Due to the vagueness associated with this definition, the use of surrogate indices to represent a measurement of the quality of care delivered in the military hospital setting will be used instead.

With the current interest in quality assurance in the health care sector being elevated as it is, there is no lack of reference data on methodologies for using various hospital indices to measure quality of care. Some of these follow. The authors Orlikoff, Fifer and Greenley (1981) write an entire book on malpractice prevention and in it, address the use of incident reporting as a tool for monitoring levels of quality. They cite an earlier work by Greeley (1979) in which he defines an incident as "any occurrence, accident or event that is not consistent with normal patient care that either did or could directly result in an injury to a patient, employee or visitor". This definition

follows closely with those standards by which incident
reports are generated in a military facility. Examples
of incidents which are recommended for use by Orlikoff,
Fifer and Greeley (1981) are sudden deaths, injury
secondary to a procedure, drug error or reaction, falls,
mishaps due to faulty equipment, dissatisfaction
regarding billing and complaints. These researchers are
not alone in their use of this type of data. Sapin,
Borok and Tabatabai (1980) cite fifty-six elements of
criteria for use in review of the quality of care
delivered in a hospital. These include preventable
deaths, drug and antibiotic review, unjustified whole
blood transfusions, preventable repeat surgery,
preventable cancellation of surgery after admission,
acceptable rates of hysterectomy's, tonsillectomy's and
adenoidectomy's, and acceptable telephone waiting times
and complaint rates. Others that recommend incident
report data are Rifkin, Lynne, Williams and Hilsenbeck
(1981); Bartilotta and Rzasa (1982); Oulton (1981); and
Kaplan and Hopkins (1980). In addition to these
researchers, medication errors as a component of
incident reports are specifically addressed by Long and
Johnson (1981).

Another measure is suggested by Martin (1981), who
specifically cites the use of infection control rates in
addition to incident reports. Use of infection rates
are also recommended by a number of other researchers.
These include Friedman (1983) and Affeldt, Roberts and
Walzak (1983). Finally, Vanaguas (1979) cites the
California Medical Insurance Feasibility Study. In
this study items such as readmissions, mortality rates,
hospital-incurred trauma and adverse drug reactions were
used as criteria.

Once the literature was reviewed it became obvious
that a multitude of items existed within the hospital
that could be used as surrogate indices to indicate the
quality of care being delivered in the hospital. The
measures were then chosen based upon availability.

<div align="center">Research Methodology</div>

Variable Selection

The variables which were selected to serve as
surrogate measures of improved health status, the
exogenous variable, and the resources consumed in the
production of the surrogate variable, the endogenous
variables, were selected based upon their relevancy to
measures used by other researchers and their

availability in the military health care system. The
frequency of the variable was decided to be monthly
versus quarterly because of the greater sample size that
this allowed for in each facility. In the old hospital
24 elements of data were then available and nine in the
new hospital. Additionally, monthly data also provides
the advantages of greater detail than that of quarterly
data.

Exogenous Variable

The measure chosen to serve as the surrogate
variable for productivity output was the Medical Care
Composite Unit (MCCU). This indice was selected because
it provided a weighting to the patient day measure and
because it was available for the entire time period of
the study. In addition to the composite value, each of
the components of the MCCU were included for study.
These are the number of admissions, beds occupied, live
births and total of inpatient and outpatient clinic
visits.

Endogenous Variables

The variables selected to represent the inputs in
the production process were selected on two levels;
resources consumed and variables representing the

quality of care being delivered in the hospital.

Resources Consumed. In keeping with the techniques used by researchers cited in the literature review, operating costs and manhours were selected to represent the resources consumed in the production process. Operating costs were determined through the use of a United States Army accounting methodology which categorizes costs through the use of their elements of expense (EOE). This system of accounting is specified in Army Regulation 37-100 and is defined as:

"a system of classifying the type of service, goods or other items being procured or consumed according to its kind rather than its purpose. Thus personal services or supplies are classified as such even though they may be used to -

> manufacture equipment;

> erect structures; or

> carry out a grant program that involves

furnishing services or material rather than

cash." (p. 8)

This means of classification was selected because it provides for the accounting of actual expenses in a very detailed manner. Eleven elements within the elements of

expense accounting system were selected to represent
hospital operating costs. These are:

EOE 1110 - Civilian Pay

EOE 1199 - Military Pay

EOE 1200 - Personnel Benefits

EOE 1321 - Severance Pay

EOE 2000 - Contractual Services and Supplies

EOE 2100 - Travel and Transportation of Persons

EOE 2200 - Transportation of Things

EOE 2300 - Rents, Communications and Utilities

EOE 2400 - Printing and Reproduction

EOE 2600 - Supplies and Materials

EOE 3100 - Equipment

These were totaled to form another variable which was
called operating cost, representing the total monthly
operating cost for each facility.

None of these figures were adjusted for inflation
due to the fact that the inflation rates had been low
and stable over the time period of the study. The rates
were estimated at 4 percent for 1984, 3.8 percent for
1985, 2.8 percent for 1986 and 3.8 percent for the first
quarter of 1987. These estimates were obtained from The
Current Business Situation section in Survey of Current

Business.

Manhours were determined through the use of data obtained from the Uniformed Staffing Methodology (USM) system. A total manhour figure was computed for each month by adding all departmental totals excluding those areas where direct manhours were not used to provide hospital services. Areas not included were the Dental Activity dental clinics and headquarters, with the exception of the Hospital Dental clinic which provides oral surgery services within the hospital; and the Veterinary Activity which provides support to the installation through food inspection and animal care, but does not provide direct service to the hospital. Those monthly totals were then adjusted for the number of days in the month and for the reduction of available work hours due to legal holidays. This was accomplished by dividing the total number of hours computed earlier by the average number of available hours for staff members that month.

Quality of Care. Since the quality of care delivered in the facility can be seen as a function of the resources consumed in the production process as well as a factor in determining the productivity level, these

variables were determined to be endogenous variables, and intermediate inputs and outputs in the production process. The review of the literature pointed to no one indice which might serve as an aggregate variable to represent the quality of care, so a variety of indices were selected. The most commonly referenced method was the use of the incident reporting system. Since this is a reporting mechanism which has been widely used for many years in the Army health care system, this appeared to be an appropriate selection. Incidents reported through this system are divided into a number of categories: medication errors, equipment failures, suicides, fires, thefts, alcohol related incidents, treatment errors, procedural or test errors, falls, altercations and complaints.

In the Fort Carson facilities, some of these indicators are not used and some are reported with such infrequency that not all of these categories were available for study. The categories included for study were medication errors, falls, procedural/test errors, treatment errors and equipment failures. All other incidents reported were combined into the variable "other".

In addition to incident reporting, iatrogenic infection rates were included as a variable for study. The literature strongly supports the use of this variable and although this data was not available for a total of five months during the study, it was considered to be critical enough to include it for study.

Lastly, patient satisfaction was a concern. Data most easily obtainable in this area for the entire period of the study was contained in the Patient Representative's quarterly report on patient complaints and requests for assistance. Although this report is prepared on a quarterly basis, the information contained within is broken down on a monthly basis.

Database Preparation

Data elements were collected on a monthly basis for the period August, 1984 through April, 1987 with the exception of infection rates which were not available for the months of May, June and July, 1986 and March and April, 1987 due to the absence of the Infection Control Nurse. Each month's set of data was designated by month, year and hospital. The missing infection control data elements were designated as missing values rather than given a value of zero.

A review of the data elements was done and it was
determined that elements which contained negative
numbers would be considered as outliers and would also
be designated as missing values. These elements only
occurred in the component elements of the operating cost
variable. Their occurrence was purely a result of
accounting technique whereby reimbursements exceeded
expenditures within that element of expense for that
month. It was contemplated that a zero value be placed
in each of these cells, but because of the unknown
degree to which the other elements were influenced by
reimbursements, the decision was made to assign them as
a missing value.

In addition to these adjustments, a separate
aggregate operating cost variable "dollars" was
computed. This variable included only those elements of
the operating cost components considered by other
researchers to have importance as discussed in the
literature review. The elements included in the
variable dollars were civilian pay, supplies and
materials, equipment, personnel benefits, and
contractual services and supplies. The only category
which was not included that was considered by other

researchers to be useful, was military pay. This portion of salaries paid was not included because it is not a controllable variable by hospital administration. Both the number of military personnel assigned and their rank, upon which their pay is based, are determined at a higher level within the Army's organizational structure.

Two other variables were computed to assist in the statistical analysis. These were called MCCU-Operating Cost and MCCU-Dollars. The computation of these variables was accomplished by the division of MCCU's reported for each month, by the figure calculated for the variables Operating Costs and Dollars, respectively, for that same month. This gave a ratio figure for each month which could then be compared against each other across both hospital facilities.

Lastly, one final manipulation of the data was made to adjust for missing data in the new hospital. Since data was not yet available for the months of May, June and July, in the new hospital, the data for these months were deleted for both years in the old hospital. This was done to account for seasonal variation which may have occurred during these months in the old hospital

data for which comparable data was not available in the new hospital. This adjustment is referred to as a seasonal adjustment to differentiate it from the other adjustments for missing data.

Statistical Analysis

Statistical analysis was performed through the use of the program Statistical Package for the Social Sciences (SPSS). The initial tests performed were basic statistical tests to determine mean, variance, range, standard deviation, and standard error. These were computed both before and after negative elements had been declared missing values. Following this, Pearson's Correlations were computed for all variables with both hospital's data combined, and then separately as the old hospital and the new hospital. This same technique was then used after having adjusted for seasonal variations. Lastly, a stepwise regression analysis by hospital was run after having adjusted for negative numbers and seasonal variation.

Research Results

Table 1 lists the correlation coefficients for the four variables considered to be most critical in the determination of productivity. The correlations were

computed for like variables at both hospitals. These are shown to demonstrate the effects that seasonal variation can have on productivity in the health care sector. It is apparent that significant relationships exist in all of these comparisons, but the variable Operating Costs in the new hospital, and that relationship is close to meeting the .05 significance level. However, differences in these relationships occur when the data is adjusted for seasonal variation. This change is particularly noticeable in the differences that occur in the variables of Dollars and Manhours. These two variables actually have opposite results after the seasonal adjustment. The strength in the relationship of Dollars between both hospitals drops to a significance level of $p<.05$, while the relationship strengthens to a significance level of $p<.01$ with the variable Manhours between the hospitals. This data is presented to demonstrate that seasonal variation has an effect on productivity in the health care sector, thereby justifying the use of seasonally adjusted data throughout the remainder of the study.

Table 2 presents the results from hypothesis testing. In each of these the null hypothesis was

that the mean for that variable in the old hospital
equaled that of the mean of the same variable in the new
hospital. The results show that any differences in the
variable representing output, MCCU's, can be attributed
to chance. However, all the variables representing
inputs do not demonstrate the same probability. The
changes in Operating Costs can also be attributed to
chance, but it must be noted that this variable is a
composite of many other variables that had contained
negative numbers and have since been adjusted for with
the use of missing values. Because of this, caution
must be used in the reliance on it for any critical
analysis.

When the results are reviewed for both Manhours and
Dollars, it can be said that with 95 percent confidence,
any change in the new facility in these two variables is
not due to chance. Without further evaluation, this
suggests that greater amounts of input are realizing
equivalent outputs in the new hospital when compared to
the old hospital.

With the computation of Pearson's Correlation
Coefficients, greater detail in the relationships
between variables can be seen. Table 3 reports the

relationships between a variety of variables

representing resources consumed and the output variable,

MCCU's.

When each of the resource variables is examined in

its relationship between MCCU's in both hospital

facilities, a reversing of the relationship is suggested

in four out of the nine variables when the statistics

are compared between the old and the new hospital. In

the variables that do not reverse their relationships,

dramatic changes occur in the degree to which the

relationships approximate a straight line. Since a

perfect fit of the data elements to a straight line

would result in a relationship of one, then the straight

line denotes that each data element lies on that line.

Table 3 shows a significant approximation of this

straight line relationship which changes to a poor

approximation of the line in the new hospital in the

variables Civilian Compensation, Dollars and Manhours.

This could be a function of the change in sample size,

or it could be favorable information if the data

elements are dropping away from the line and not rising

up from the line. A dropping away would denote a

reduction of these inputs to produce the same outputs,

since the hypothesis testing reported no differences in the means of the MCCU's between the new and the old hospital.

To get an accurate picture of the actual resource consumption, Figures 5, 6 and 7 are provided to demonstrate which direction the data elements are moving from the line that was approximated in the old hospital.

Figure 5 demonstrates that the fiscal year of 1987, which begins on October 1, 1986, brought a dramatic increase in spending and then in reimbursements in the months of October and November. Aside from these variations, the data elements appear to be very similar to those in the old hospital. This suggests that a change in the correlation was probably more due to the two outliers in October and November than due to any trend in spending changes.

Figure 6 demonstrates a continuing spending increase in civilian compensation. However, the general slope of the line drawn between the points, begins to level off after the move to the new facility. This does not mean that the dollar input for civilian compensation is in a better ratio to MCCU's, but rather, it shows a trend of reduction in spending increases that had

occurred in the old hospital.

Figure 7, which provides a picture of the labor expended in both hospitals, shows an increase from the data collected in the early months of the study, but the manhours seem to level out, or possibly decrease as compared with the months in early 1986.

The results in these figures and table then provide a better idea that with MCCU's remaining constant, there has been fairly constant input of manhours and dollar spent with the exception of civilian compensation. When this is then combined with the possibility of the reversing relationships in four other variables, table 3 summarizes an instability in the new hospital environment versus the trends in the old hospital when aggregate data is reviewed.

With the lack of any definite trend noted in productivity variables, the quality of care variables take on an added importance. If a trend of increasing quality of care is being delivered, it might explain the lack of increase in productivity.

Table 4 and 5 present Pearson's Correlation Coefficients for the quality of care variables. From the data presented in Table 4, it would appear that

infection rates and MCCU's were more closely
approximating a straight line relationship in the new
hospital. However, when Figure 8 is reviewed, it is
can be seen that no trending in infections has occurred
in either hospital.

This same scattering of data points in both
hospitals occurs in the variable Falls, which can be
seen in Figure 9. This suggests that the occurrence
trend in the new hospital is not much different from
that of the old. The differences in correlation
significance levels in these two variables can most
probably be attributed to differences in sample size.

Figure 10, on the other hand appears to show an
increase in medication errors in the new hospital.
Table 4's figures show that no statistically significant
relationship between MCCU's and Medication Errors
exists in either hospital. This suggests that
medication errors fluctuate irrespective of workload
changes. This is not a result that would be anticipated
in most settings, but would have lent some credence to
the hypothesis that quality was increasing if it had
done otherwise.

When patient satisfaction variables are considered,

Table 4 shows no statistically significant relationships between Patient Complaints and MCCU's and Requests for Assistance and MCCU's. Figure 11 once again shows a scattered plot of Patient Complaints in both the new and the old facility. However, if the data points are scrutinized after the move, it can be seen that a drop in the number of complaints were reported after the initial three months. This could be attributed to a familiarization of the procedures and layout in the new hospital by the patients.

Table 5 presents these same quality of care variables as intermediate output measures, and their relationships to the input variables Manhours and Dollars. Since neither of these two input variables can be assumed to be equal in the old and the new hospital, graphing of this data would require the addition of a third axis to incorporate their effect on the quality of care variables. Since it was not possible to present that in this paper, this table will be discussed without any supporting graphs. Medication and Procedure Errors indicate a significant relationship to manhours, which increased in the new facility, but no significant relationship was noted for either of these variables in

the old hospital. Requests for assistance indicated a
significant decrease as manhours increased in the old
facility and in the new facility virtually no
relationship exists between these two variables.

The Dollars variable indicates that only the
variables of Equipment Failure and Other have
significant relationships with dollars spent in either
facility. Table 5 shows that equipment failures were
significantly negatively correlated with the dollars
spent in the old hospital and were not in the new. This
is the opposite of what occurred for all other incidents
reported. Equipment failures would be expected to
decrease as more dollars were spent if it was being
spent on new equipment and maintenance contracts.
However, it should not be expected to have a significant
relationship in the old hospital and then not in the new
where new equipment was purchased almost universally
across the hospital. The reason for this change may
then be the decrease in sample size in the new
hospital. The change from a nonsignificant to a
significant relationship of all other incidents in the
new hospital may be attributed to an increased
consciousness on the reporting mechanism which was

brought about by the hiring of a Risk Management Coordinator and an impending accreditation survey by the Joint Commission on Accreditation of Hospitals. The point to note from this table is the instability between the two hospitals in all the variables reporting significant relationships in one or the other of the two hospitals.

The last set of tests confirm this lack of settling in the new facility. Table 6 shows a coefficient of determination for the labor and money spent in the old facility as explaining 45 percent and 49 percent of the variation in MCCU's respectively. In the new facility, the coefficient indicates that only 1 percent and 2 percent of the variation in MCCU's is explained by the same two variables respectively. These results suggest that a tremendous change in the production process has occurred in the new hospital. This is particularly evident when the beta values for manhours are examined. In the new facility, the beta value indicates that for every one unit increase in labor, MCCU's decrease by an increment of .16507. Figure 13 graphically shows this occurring after the move into the new facility. This is particularly important to note because no matter how

drastic a change in the production process had occurred,
one would still not expect to see that increased labor
creates decreased production outputs.

Chapter III

Conclusion

Overall, the aggregated data suggests that there was a failure to show any significant increase in the amount of productive output, MCCU's, in the new facility. In addition, the relationship between consumption of resources and the production of MCCU's in the new hospital provides very little explanation for production output, at least as measured in this study, despite the fact that considerable variation in output in the old hospital was explained by these same variables. The beta values of the regression analysis suggest that in the new hospital, increased manhours result in a decrease in MCCU's; and dollars spent only produces approximately half the increase in MCCU's that it did in the old hospital. Therefore, a move to a new more modern design of hospital facility has not, in a period of nine months, produced an increase in productivity. Whether this failure to become more productive could be explained as resultant from an increase in the quality of care being delivered depends upon which variable is examined. The indices studied through the use of scatter diagrams indicated that the

only area where quality of care could be said to have increased was that of requests for assistance due to a decreasing trend over the time period of the study. However, all other variables appear to demonstrate the same pattern throughout the time period of the study or become progressively worse over time such as occurs in the variable Medication Errors. This variable alone is a significant indicator of the quality of care being delivered. Therefore, it is questionable whether the statement could be made that an increase or decrease in the quality of care was seen in the new facility.

Explanations for these findings could be numerous, but the most logical explanation is that the learning curve or production function has had significant effects on the capability of the hospital employees to produce at an optimum level during the nine months of the study in the new facility.

The fact that this curve had such a profound effect may partially be attributed to the fact that 28 percent of the staff failed to attend any transition training which was conducted by the construction project office prior to the move. This figure was obtained from the Transition Training After Action Report for Evans Army

Community Hospital, dated 14 October, 1986. With over 1/4 of the staff unfamiliar with the new facility on move-in day, the learning process may well have been lengthened considerably. This impact on the initial productivity in the facility may have had a major influence on the aggregated data in the new hospital.

Another critical factor which could have had considerable impact on the productivity levels in the first few months in the new facility may have been the large turn-over in staff. Within the months of August through December 1986, the initial move-in period in the new facility, the hospital had a total loss of 21 personnel from the profes ional staff, three of which were physicians. In replacement for those losses, the hospital experienced a gain of 20 personnel, of which five were physicians. Since the total authorization for professional staffing within this organization is 158 personnel, the hospital experienced a 13 percent turnover in the professional staff in a period of five months. This turnover rate most likely had considerable impact on the efficiency of the production process in the first months of the new facility.

Recommendations

The results of this research suggest that it is too early to obtain sufficient data past the time of the initial learning period in the new hospital. Therefore the recommendation is made that additional study be done to determine when the learning curve begins to level out in a new facility. Then a more appropriate study could be done to determine if that level of productivity is significantly different from that of the old facility. To discover these findings considerable more time would be needed in a new facility so that a sufficient sample size could be maintained as one month at a time is backed out of the regression analysis to discover these relationships. The findings, however, would give us a considerable advance in our knowledge of productivity in the health care sector.

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Table 1. Pearson's Correlation Coefficients -
Comparison of Seasonal Variations.

Critical Variables	Before Adjustment	After Adjustment
sample size	33	27
MCCU	.3824*	.3423*
Operating Cost	.2922*	.2964~
Dollars	.5255**	.3843*
Manhours	.3205*	.5968**

*$p<.05$.   **$p<.01$.   ~$p=.067$

Note: Data is adjusted for outliers by assignment as missing values.

Table 2. Hypothesis Test Results

Variable	t Test Value	Decision
MCCU	-1.822	fail to reject H_0
Operating Cost	-1.552	fail to reject H_0
Manhours	-3.719	reject H_0
Dollars	-2.082	reject H_0

H_0:mean of old hospital equals mean of new hospital.

H_1:mean of old hospital does not equal mean of new hospital.

$t_{crit\ .05}$ two-tailed test = +/-.064.

<u>Note</u>: Data has been adjusted for seasonal variation and outliers.

Table 3. Pearson's Correlation Coefficients -

Resources Consumed.

Resources Consumed˜	MCCU˜˜	
	Old	New
Sample Size	18	9

Budget

Civilian Pay	.4974*	.1976
Military Pay	-.2467	.5013
Personnel Benefits	.2969	.7885*
Contractual Services	.1636	-.0441
Supplies & Materials	.2972	-.3558 (8)
Equipment	.2329	.1043 (8)
Operating Costs	.1585	.1424
Dollars	.4223*	-.1156

Labor

Manhours	.6728**	.0435

˜Independent Variable.   ˜˜Dependent Variable.   *p<.05.   **p<.01.

Note: Data adjusted for seasonal variation and outliers.

Sample sizes as listed except where noted by parenthetical

entries.

Table 4. Pearson's Correlation Coefficients -
Quality of Care.

Quality of Care Indices~	MCCU~~	
	Old	New
Sample Size	18	9
Infection Rate	.1786	.5626 (7)
Incident Reports		
Medication Errors	.3061	.4777
Falls	.6115**	.0962
Procedure Errors	-.0322	-.1924
Treatment Errors	-.2091	-.4438
Equipment Failures	-.2557	-.4363
Other	.2400	-.2179
Patient Satisfaction		
Complaints	.0777	-.4392
Request for Assistance	-.0502	.3800

~Independent Variable.   ~~Dependent Variable.   **p<.01.

Note: Data adjusted for seasonal variation and outliers.
Sample sizes as listed except where noted by parenthetical
entries.

Table 5. Pearson's Correlation Coefficients - Quality of Care.

Quality of Care Indices[~]	Manhours[~~]		Dollars[~~]	
	Old	New	Old	New
Sample Size	18	9	18	9
Infection Rate	.2672	.6437 (7)	.1786	.5626 (7)
Incident Reports				
Medication Errors	.3596	.5865*	.1255	-.2078
Falls	.0858	.0937	.3081	.3815
Procedure Errors	.0741	.7041*	-.0598	.2756
Treatment Errors	-.2874	.2298	-.2122	.3110
Equipment Failure	-.3126	-.3152	-.4619*	-.4012
Other	.2059	.1136	.3254	.6662*
Patient Satisfaction				
Complaints	.0833	-.0368	.0328	.3389
Request for Assistance	-.5217*	.0208	-.2751	-.1826

[~]Dependent Variable. [~~]Independent Variable. *$p<.05$. **$p<.01$.

Note: Data adjusted for seasonal variation and outliers. Sample sizes as listed except where noted by parenthetical entries.

Table 6. Multiple Regression Analysis.

| | Hospital | | | |
| | Old | | New | |
	R^2	Beta	R^2	Beta
Manhours	.45271	.59852	.01336	-.16507
Dollars	.49643	.22191	.02407	.11474

Note: MCCU is the dependent variable. Data has been adjusted for seasonal variations and outliers.
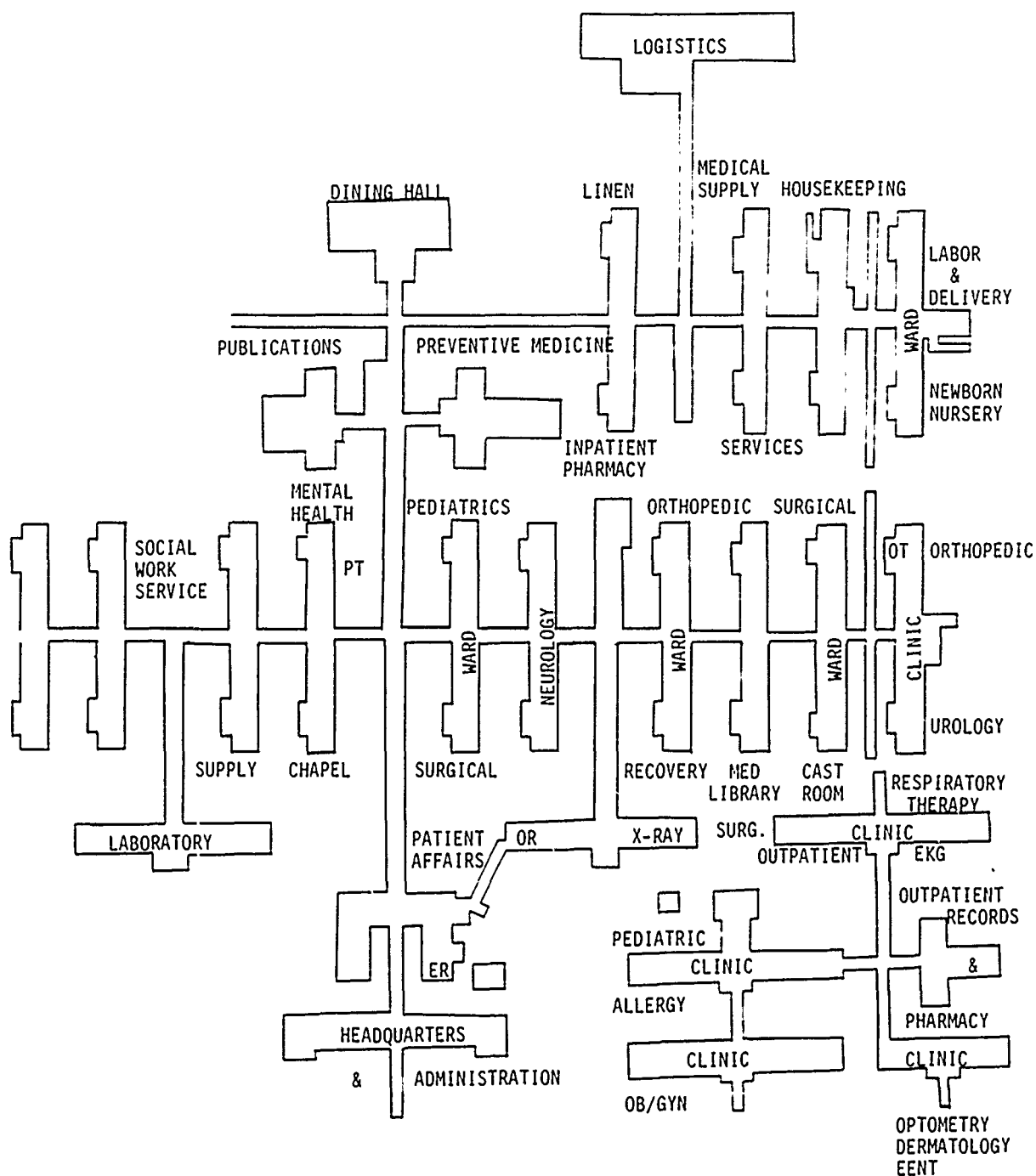
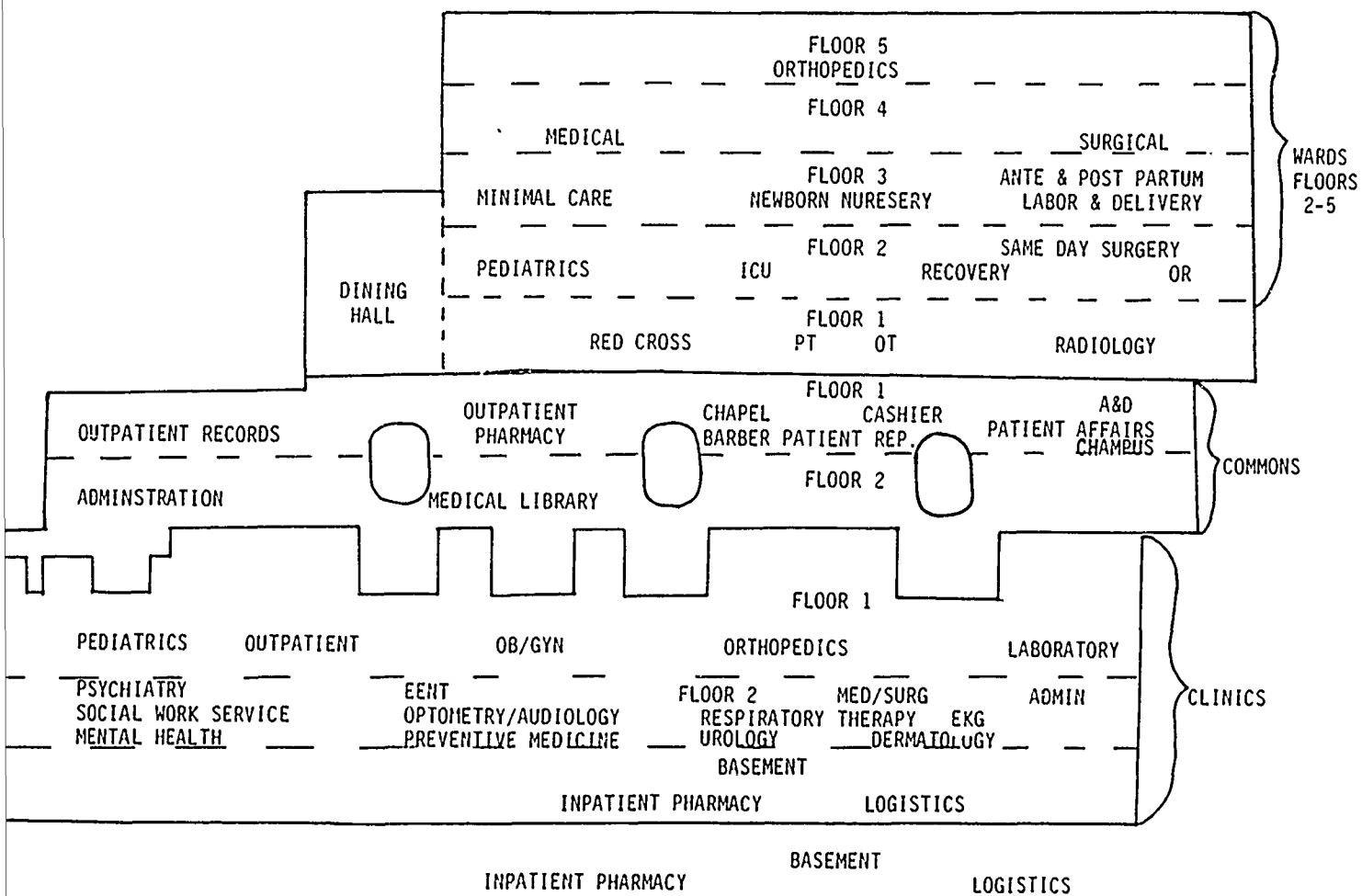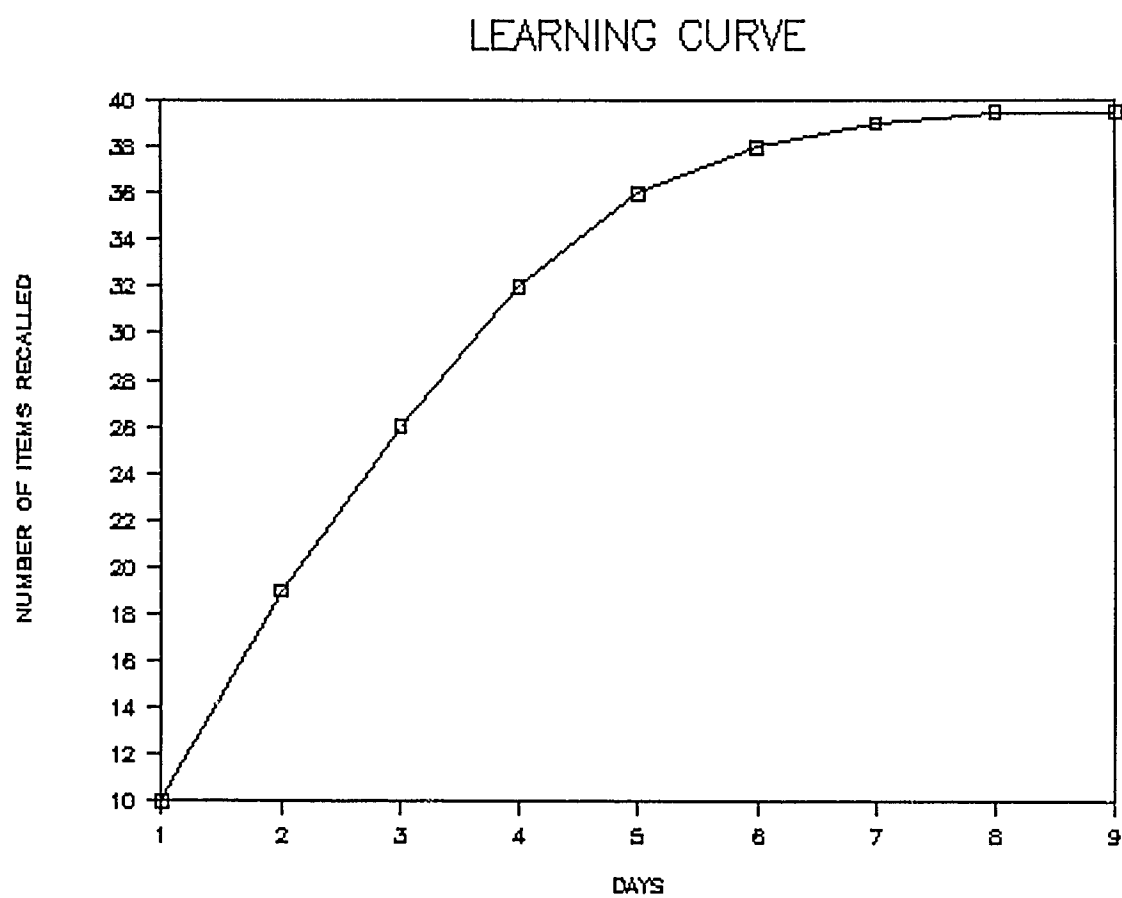Figure 1. Layout of Old Hospital

Figure 2. Layout of New Hospital

FLOOR 5
ORTHOPEDICS

FLOOR 4
MEDICAL   SURGICAL

FLOOR 3   ANTE & POST PARTUM
MINIMAL CARE   NEWBORN NURESERY   LABOR & DELIVERY

FLOOR 2   SAME DAY SURGERY
PEDIATRICS   ICU   RECOVERY   OR

FLOOR 1
RED CROSS   PT   OT   RADIOLOGY

WARDS
FLOORS
2-5

DINING
HALL

FLOOR 1
                    OUTPATIENT   CHAPEL   CASHIER   A&D
OUTPATIENT RECORDS PHARMACY   BARBER PATIENT REP.   PATIENT AFFAIRS
                                                                CHAMPUS

ADMINSTRATION   MEDICAL LIBRARY   FLOOR 2

COMMONS

FLOOR 1

PEDIATRICS   OUTPATIENT   OB/GYN   ORTHOPEDICS   LABORATORY

PSYCHIATRY   EENT   FLOOR 2   MED/SURG   ADMIN
SOCIAL WORK SERVICE   OPTOMETRY/AUDIOLOGY   RESPIRATORY THERAPY   EKG
MENTAL HEALTH   PREVENTIVE MEDICINE   UROLOGY   DERMATOLOGY
                                          BASEMENT

CLINICS

INPATIENT PHARMACY   LOGISTICS

BASEMENT
INPATIENT PHARMACY   LOGISTICS

Figure 3. Learning Curve

LEARNING CURVE

Figure 4. Production Curve

PRODUCTION CURVE
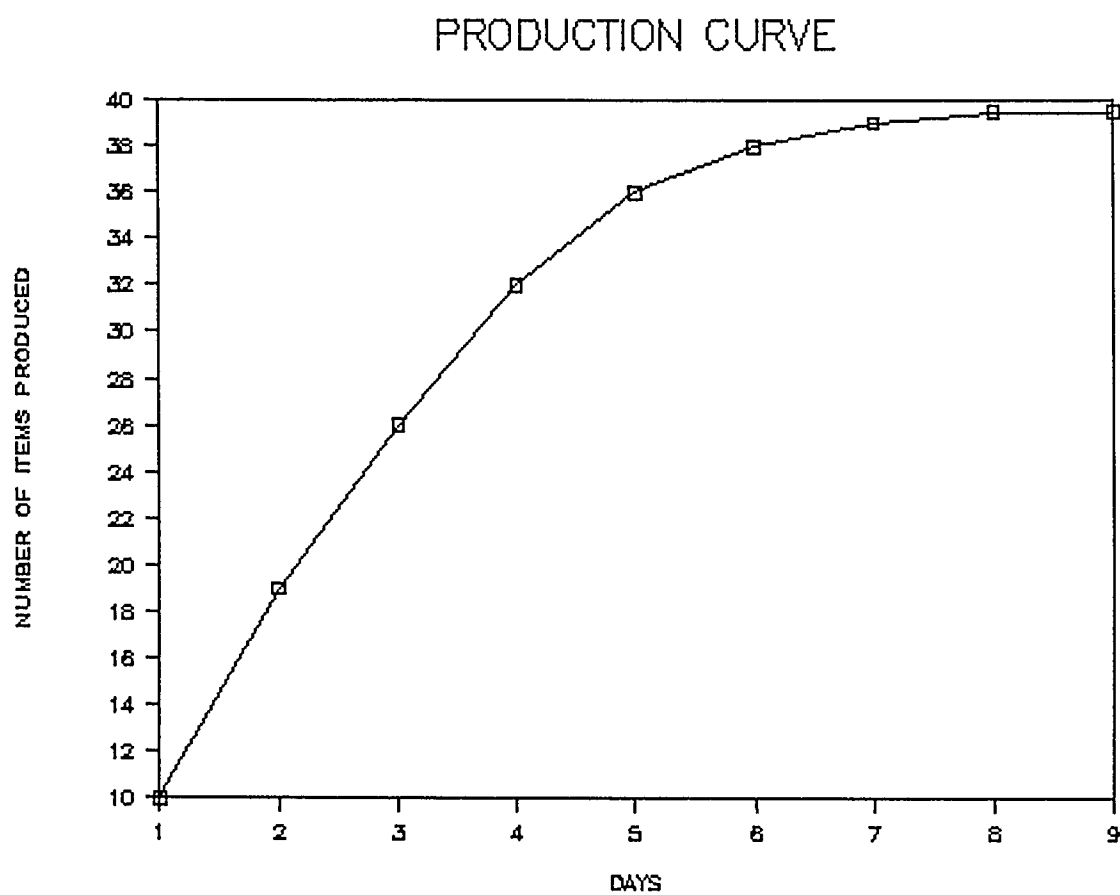
Figure 5. Dollars

DOLLARS
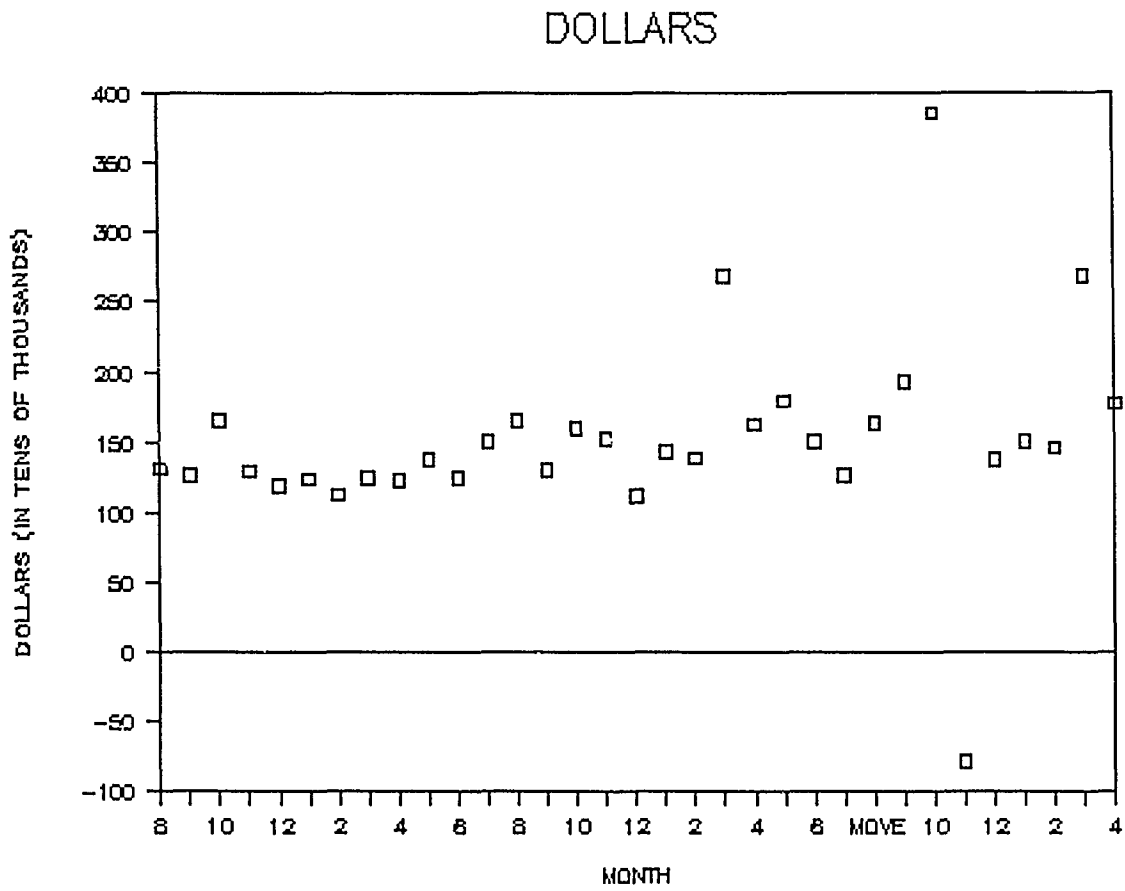
Figure 6.   Civilian Compensation

CIVILIAN COMPENSATION
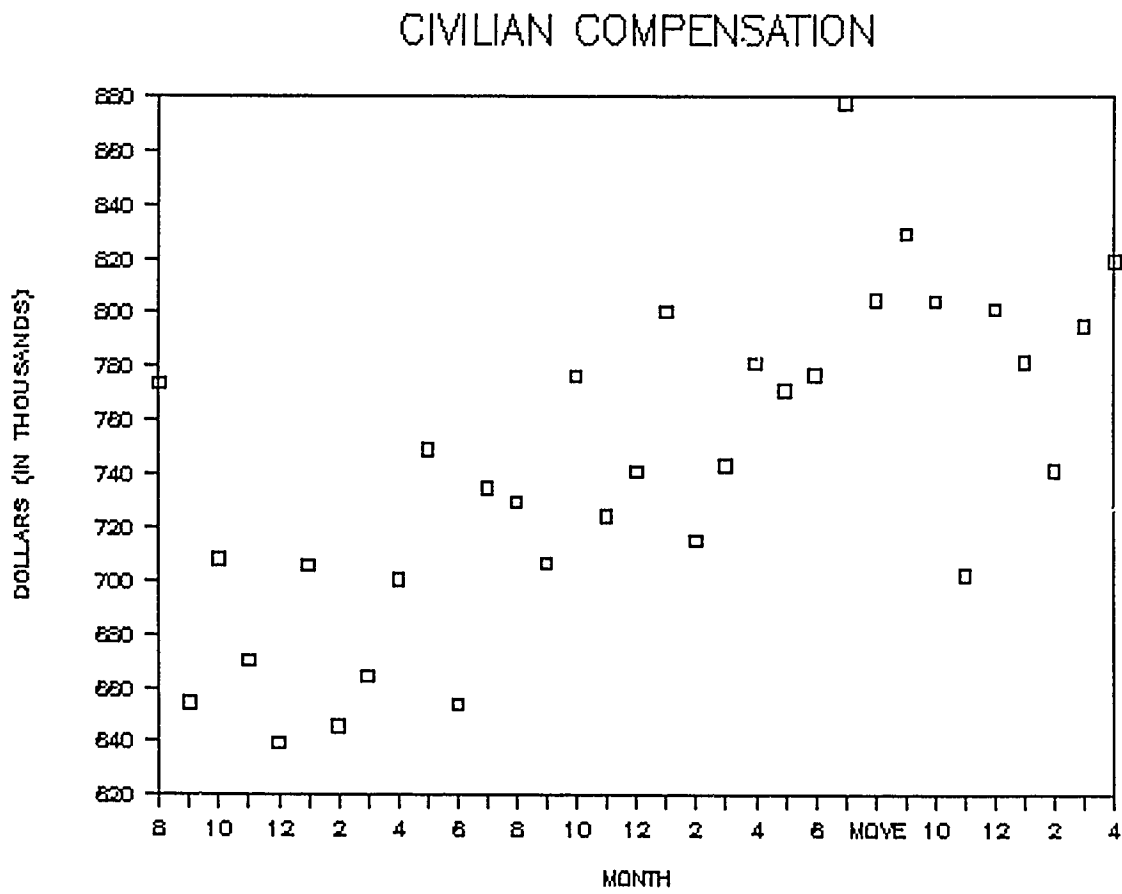
Figure 7.   Manhours
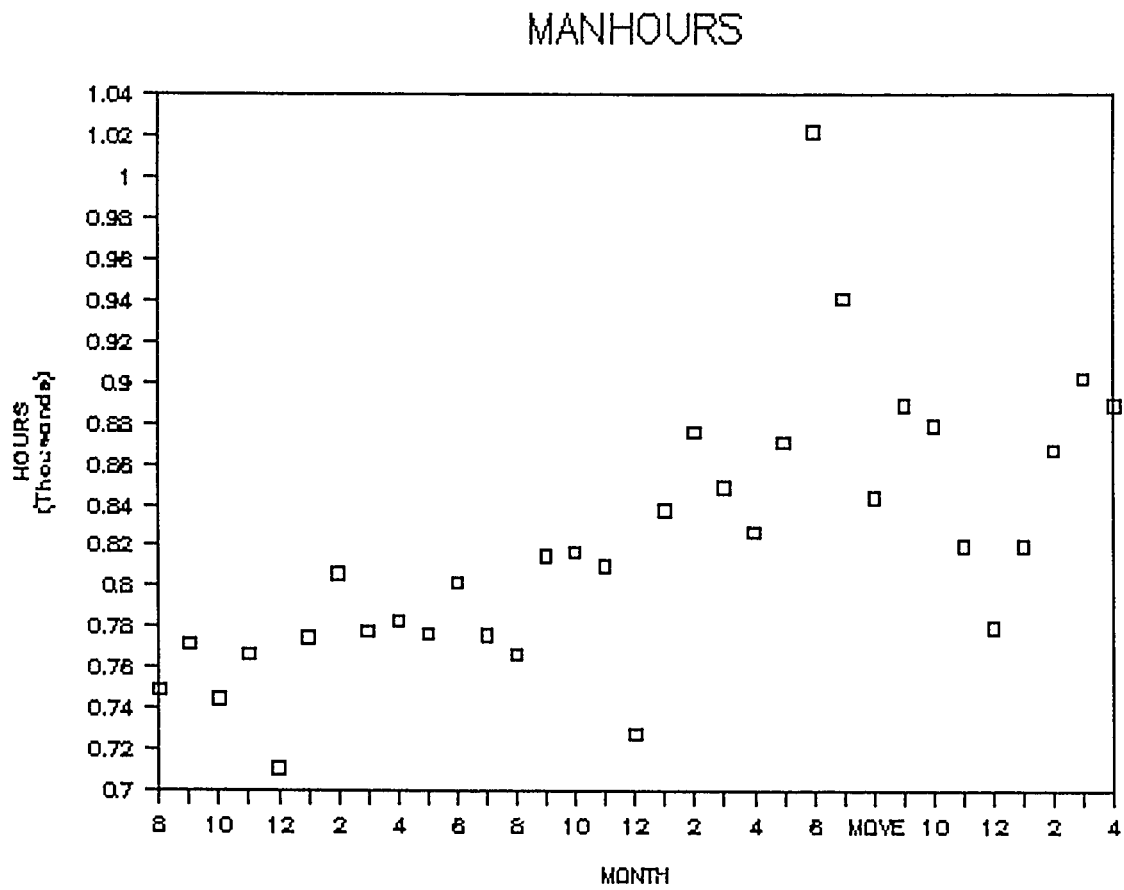
MANHOURS

Figure 8.   Infection Rates

INFECTION RATES
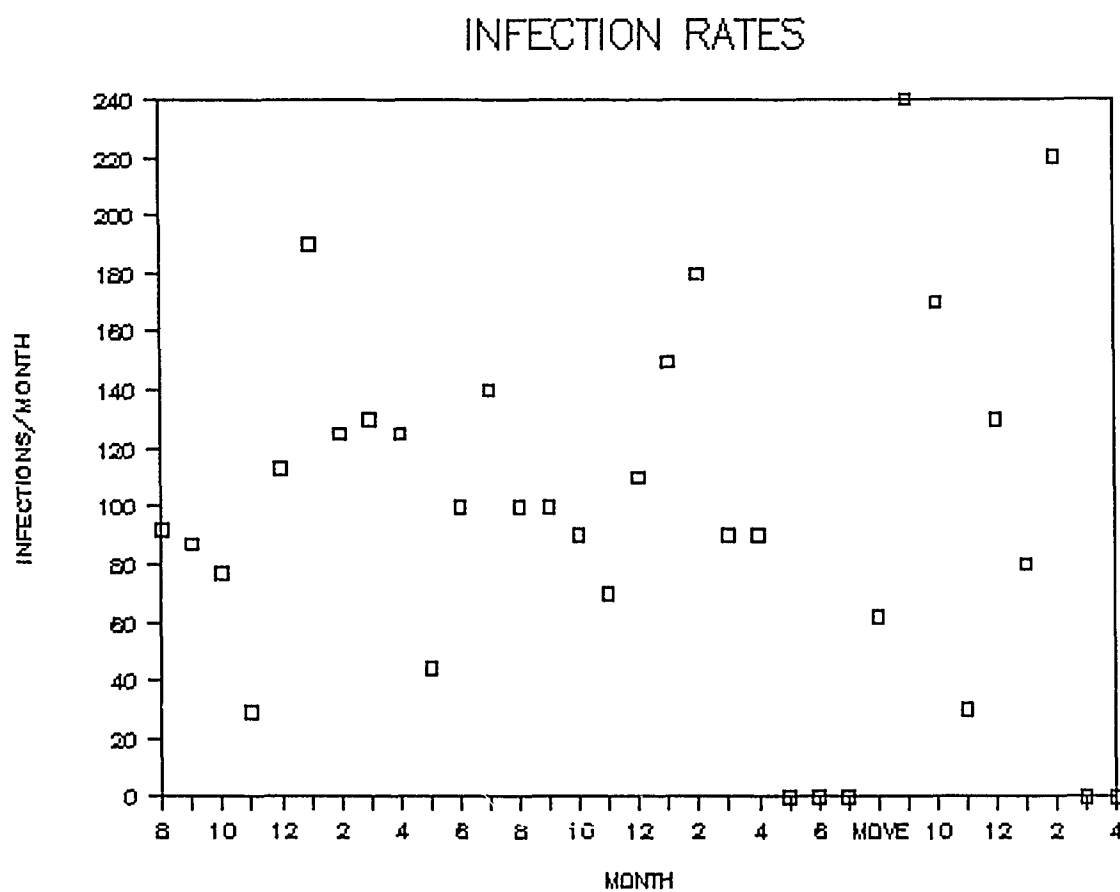
Figure 9. Falls

FALLS
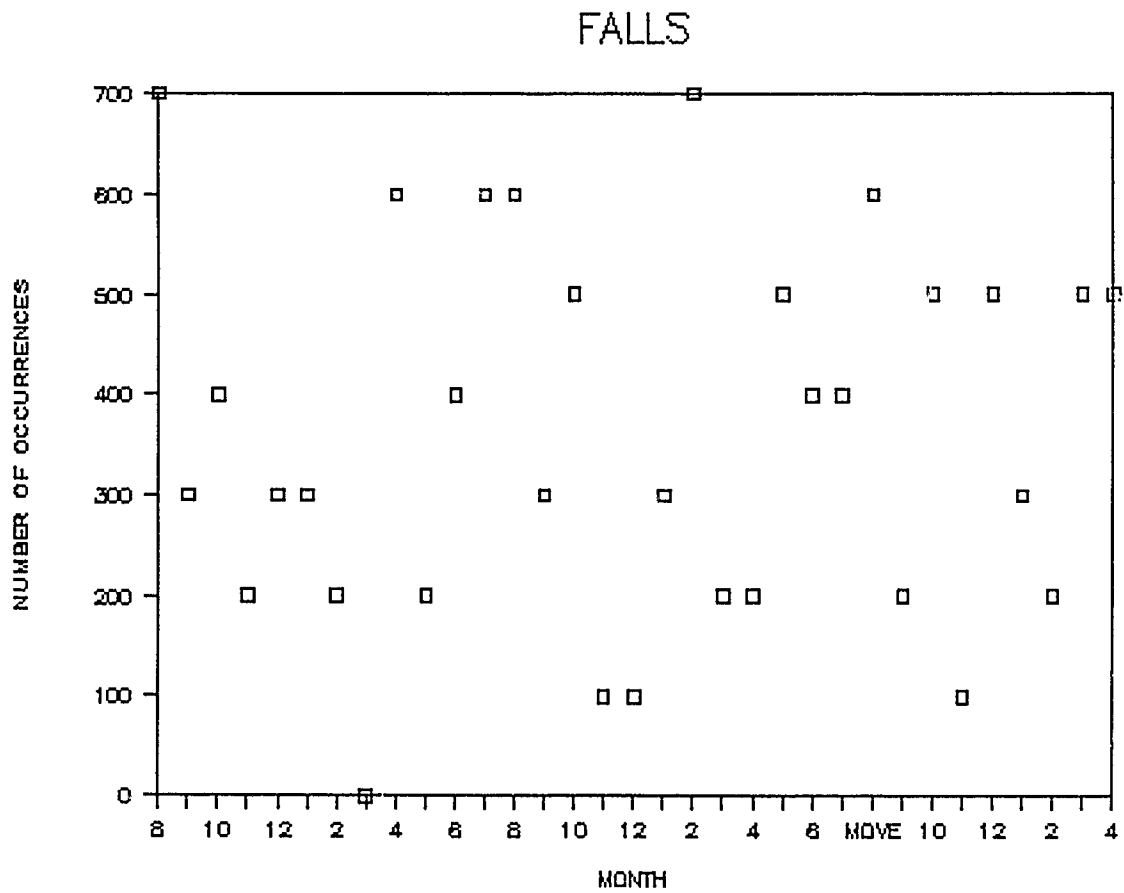
Figure 10.   Medication Errors

MEDICATION ERRORS
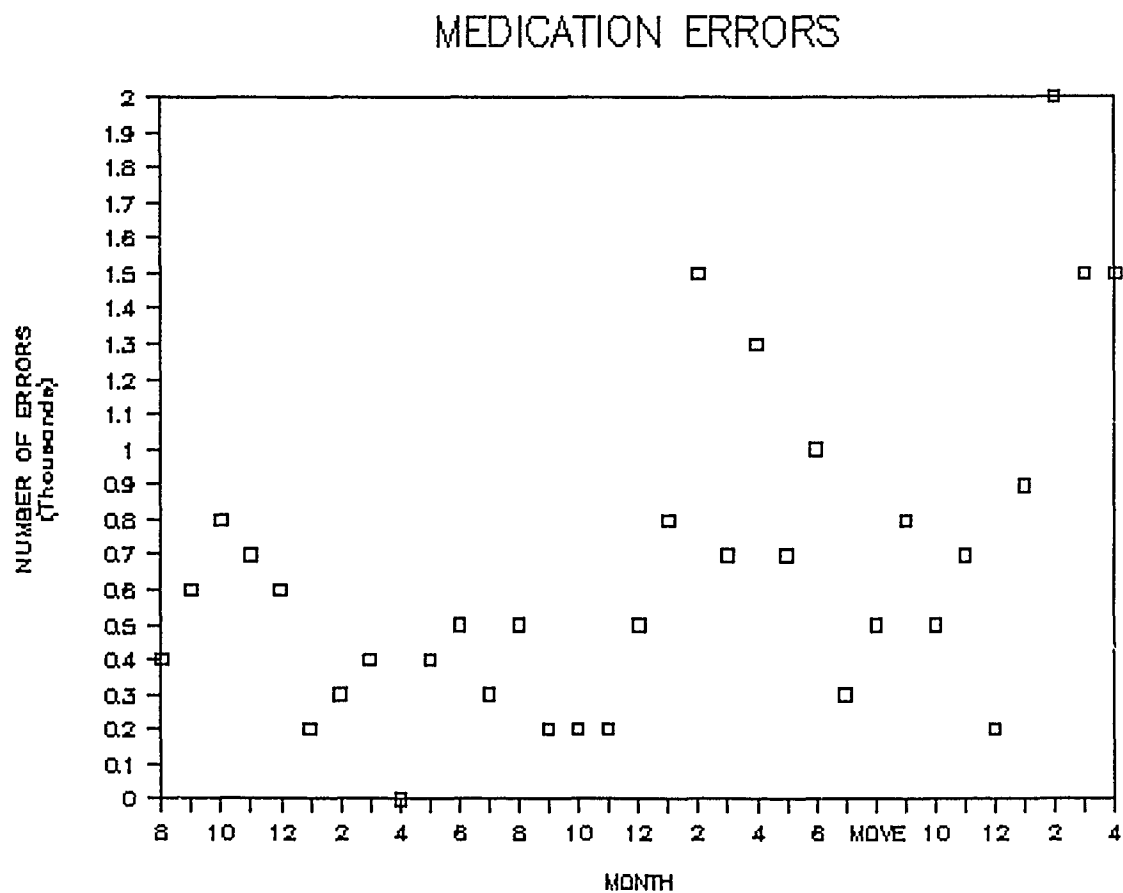
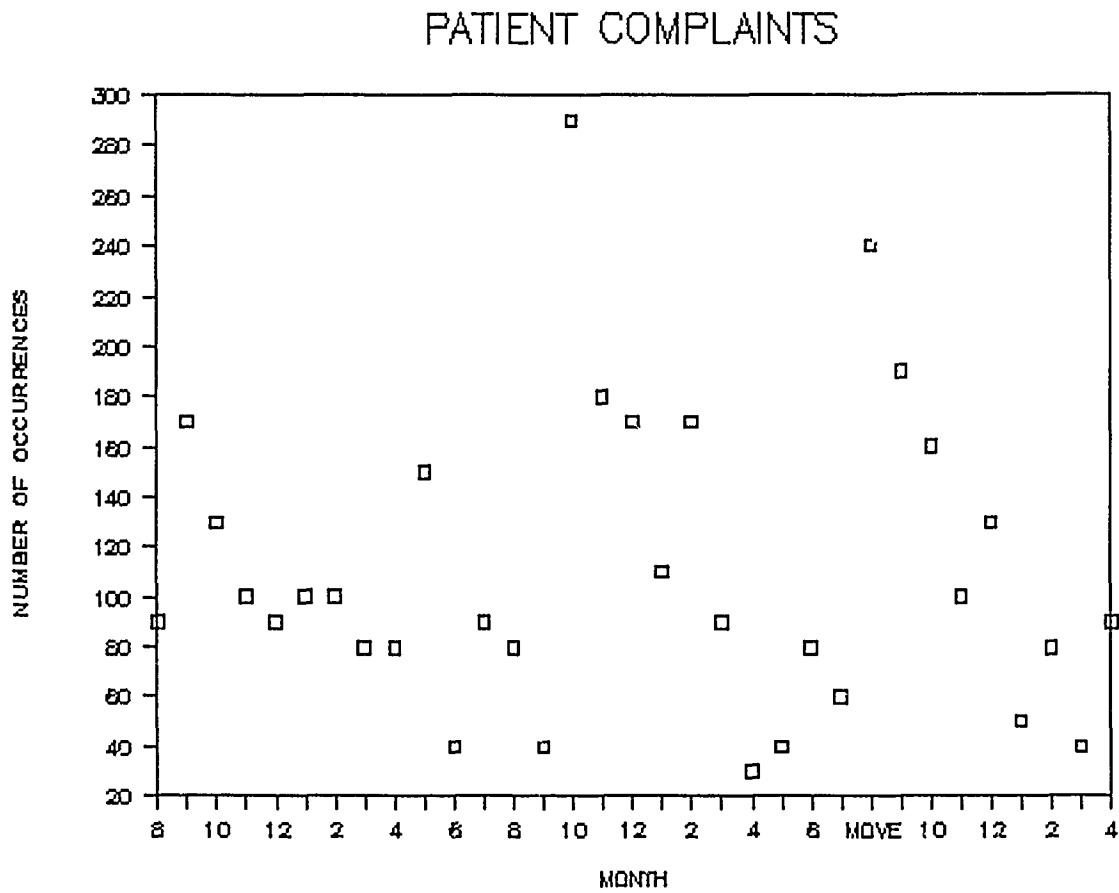Figure 11. Patient Complaints
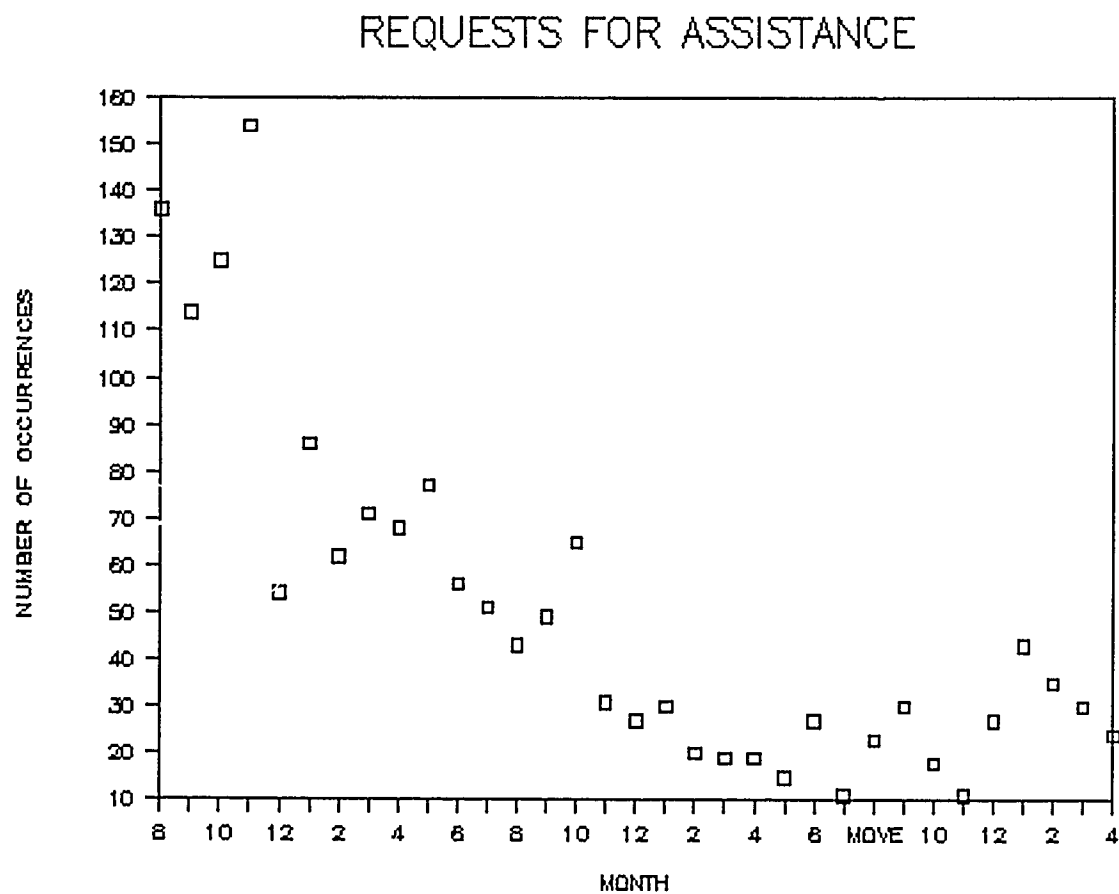

PATIENT COMPLAINTS

Figure 12.   Requests for Assistance

REQUESTS FOR ASSISTANCE

Figure 13.   MCCU's and Manhours

MCCU'S AND MANHOURS